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RESEARCH ARTICLE

# Medium and large-sized mammals in Private Natural Heritage Reserves in the Quadrilátero Ferrífero of Minas Gerais, Brazil

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## Abstract

Habitat fragmentation has been shown to be constantly growing and increasingly affecting the conservation of species that require large areas for their populations to subsist, as is the case for most large animals. In Minas Gerais, there are 45 species threatened with extinction in the Brazilian Red List and for most mammal species there is not yet sufficient data on their populations and distributions, which makes it difficult to understand their conservation status. To understand the composition of medium and large mammals in two Private Natural Heritage Reserves (RPPNs) in the Quadrilátero Ferrífero of Minas Gerais (Cata Branca and Córrego Seco), in a transition zone between the Atlantic Forest and the Cerrado, a camera trapping survey of mastofauna was carried out between November 2019 and May 2020. The combined RPPNs have a rich diversity with 20 species of medium and large mammals and provide a fundamental service for the protection of animals threatened with extinction, in addition to harbouring important species for the maintenance of local ecosystems. However, they are areas with a strong anthropic impact and have a lower richness than some other reserves also located in the Quadrilátero Ferrífero, especially Cata Branca, which had a lower richness than Córrego Seco.

## Keywords

Atlantic forest, camera trap, Cerrado, conservation units, fauna survey, mastofauna

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## Introduction

Brazil is home to 10% of the world's terrestrial biota, in addition to being considered one of the most biodiverse countries on Earth (Mittermeier et al. 1997). Brazil already has 751 known mammal species and there is a permanent expectation of discovering many other new species (Paglia et al. 2012; Quintela et al. 2020). According to the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBIO 2018a), there are 110 threatened species, representing 15% of the total evaluated. In Minas Gerais State, 238 species of mammals have already been registered. From those, 45 are under threat of extinction (Biodiversitas 2007), highlighting the need for actions aimed at their conservation in the state.

The Mammalia class is a group of animals with great ecological importance for carrying out various ecosystem services, such as population control of plants and animals (Terborgh et al. 2001), as well as seed dispersal (Stoner et al. 2007). There is still insufficient data on most mammal species, particularly on their populations and distributions, which makes it difficult to understand their real status of conservation. This means that many species can actually be threatened without us even knowing about it (Reis et al. 2010). In Minas Gerais, 18.5% of mammals are classified as "deficient in data" (Biodiversitas 2007).

The fragmentation of habitats is an important source of disturbances that can damage the biodiversity of a given location or change its distribution (Newbold et al. 2015). These threats have been shown to be in constant growth and increasingly affecting the conservation of species that require large areas for the subsistence of their populations, as many of the largest animals (Chiarello 2000). According to Terborgh and Van Schaik (2002), for biodiversity to be protected, it needs more areas designated for its conservation than the ones that already exist. Mittermeier et al. (2005) add that besides the public initiative reserves, Private Natural Heritage Reserves have proved to be a progressively important tool in the sustenance of efforts to protect biodiversity.

For the creation and structuring of good public policies that seek the conservation of species and the ecological health of a given location, it is extremely important to obtain data on the populations that live there (Pazio 2013). Therefore, this work aims to formulate a list of medium and large-sized mammal species present in two neighbouring Private Natural Heritage Reserves (hereinafter RPPNs) in an area strongly influenced by mining and urbanisation in Itabirito, Minas Gerais, Brazil (Oliveira 2013), and analyse whether there are differences in fauna composition between the two locations. To achieve this, we used camera traps.

## Methods

### Area of study

The Quadrilátero Ferrífero is located in the south-central region of the Minas Gerais State, in south-eastern Brazil. The area occupies approximately 7,000 km$^2$ and

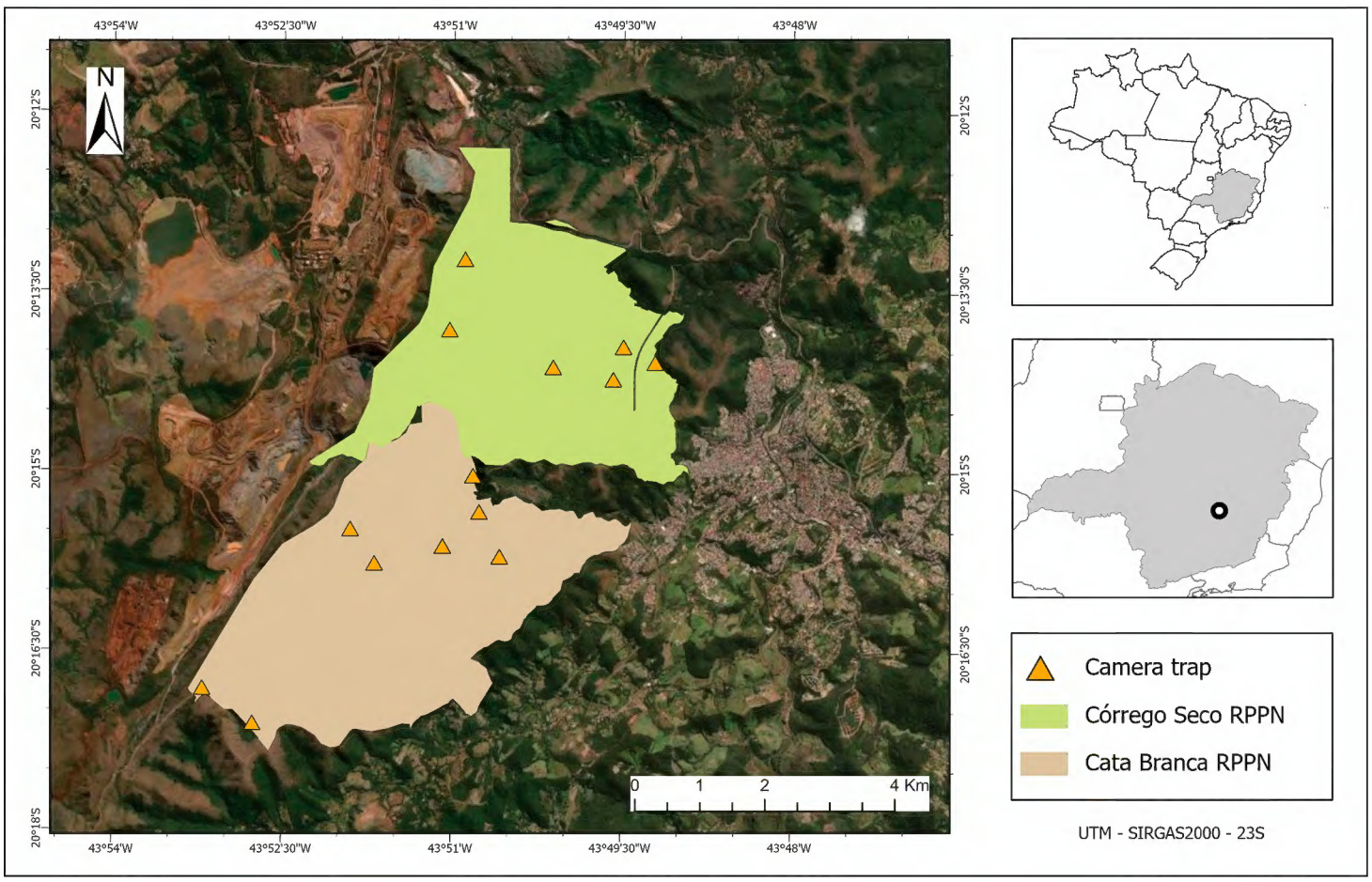


**Figure 1.** Location and delimitation of the RPPN Cata Branca and RPPN Córrego Seco, Minas Gerais, Brazil, showing the distribution of the locations of camera traps.

is considered a major supplier of ore in Brazil, with high concentrations of iron, manganese, and gold deposits (ICMBIO 2010). This region has altitudes that vary between high ridges of approximately 2,000 metres and large valleys formed by the action of rivers, mild temperatures and good levels of rain (Barbosa and Rodrigues 1967; Carvalho Filho 2008). With an altitude climate, the region is in the transition zone between the Cerrado and the Atlantic Forest, generating a great diversity of habitats and housing a remarkably high diversity of plant and animal species, in addition to having high levels of endemism. These facts classify the Quadrilátero Ferrífero as an area of extreme ecological importance (Drummond et al. 2005; Viana and Lombardi 2007).

The study was carried out in two distinct areas, but very close geographically: The Private Reserve of Natural Heritage Cata Branca and the Private Reserve of Natural Heritage Córrego Seco. Cata Branca is an RPPN owned by the mining company Vale, located in the municipality of Itabirito, Minas Gerais (Fig. 1). It is an area of 1,102.89 ha, at altitudes close to 1,300 meters and is part of the sub-basin of the Rio das Velhas, São Francisco River basin. It harbours a great diversity of phytophysiognomies, such as the Seasonal Semideciduous Forest, Cerrado and Campo Rupestre on quartzite rock outcrops (Bioma 2016).

The RPPN Córrego Seco (Fig. 1) also belongs to the mining company Vale, with an area of 1,797 ha. It is located next to the RPPN Cata Branca and the Mina do Pico, in addition to being directly connected to the Ecological Station Arêdes (Oliveira 2013). The RPPN Córrego Seco is located to the left of the Rio das Velhas river and

has a high surface water availability, being composed of the streams Carioca, Mato da Fábrica and Serrinhas. It harbours 55 springs that flow into the Itabirito river. In its area it is possible to find a considerable variability of phytophysiognomies, from Cerrados and Campos Rupestres in the highest parts of the Reserve, to Semideciduous Forests on the slopes and Ombrophile Forest in the valleys. In this way, it offers different habitats that shelter a great diversity of species of reptiles, amphibians and mammals (Oliveira 2013).

## Data collection

The study was conducted from November 2019 to May 2020, using 14 camera traps (*Bushnell Trophy Cam HD*) in forest and field areas within the two RPPN areas: 6 in Cata Branca and 8 in Córrego Seco. The points were chosen with criteria such as: possibility of access on foot, greater dispersion of sampling in the studied area and presence of animals' signs, respecting a minimum distance of radius around 800 metres from another point. In each location, a firm tree was chosen and a camera was set at a height of approximately 50 cm above ground.

The cameras were operating 24 hours a day, with the configuration of a photo followed by a 20-second video and with the sensors in automatic mode. They were inspected every 45 days to change memory cards, identify possible malfunctions and check the battery level. The cameras allocated in the field area have always been positioned to the north or south, so that they did not receive sunlight directly on their lenses at any time of the day. In addition, all presence sensor sensitivity settings (automatic, low, medium and high) have been tested to solve possible problems. Finally, protections against sunlight were placed on the cameras, as a cover, which greatly reduced the capture of images without animals (Fig. 2).

To ensure independent events, images of animals of the same species that were captured more than once within an hour, by the same camera, were counted as just one record (Bahaa-el-din et al. 2016; Sollmann 2018).

The conservation status of the mammal species recorded in this study was obtained from the List of Endangered Fauna of Extinction of Minas Gerais (Biodiversitas 2007), in Red Book of Endangered Brazilian Fauna (ICMBIO 2018b), and on the red list of the International Union for the Conservation of Nature (IUCN 2020).

## Data analysis

For the analysis, a species discovery curve (collector curve) was constructed for each location, with all data obtained in the field. The wealth estimates were established with the Jackknife I estimator, considered one of the most appropriate procedures for this type of work, since it considers the low frequencies of the less sampled species (Heltshe and Forrester 1983; Tobler et al. 2008). The relative frequency of species was calculated by dividing the number of independent events for each species by the sum of all independent events for all species. Then this number was converted into a percentage.

**Figure 2.** Camera protection against sunlight.

## Results

The sampling effort in Cata Branca was 846 trap-days; of these, 447 were in the forest area and 399 in the field area. Of the 6 cameras used in this reserve, two were stolen during data collection. The sampling effort in Córrego Seco was 1,109 trap-days, of these, 795 were in the forest area and 314 in the field area. Although 8 cameras were used, one did not work correctly, and its data and sampling time were disregarded. Therefore, the total sampling effort on both locations was 1,955 trap-days.

We obtained 189 independent events of medium and large size native mammals in both RPPNs. Domestic animals, such as horses (*Equus ferus caballus*) and domestic dogs (*Canis lupus familiaris*), were also recorded in the samples, but did not enter the statistics.

In the RPPN Cata Branca, 10 species of medium and large-sized mammals were registered in 54 independent events. Three of these species are under some type of extinction risk: *Chrysosyon brachyurus* (Maned wolf), *Puma concolor* (Puma) and *Leopardus pardalis* (Ocelot). On the other hand, at RPPN Córrego Seco, 17 species of medium and large-sized mammals were recorded in 135 independent events (Table 1). The species *P. concolor* and *L. pardalis* were the threatened species found in this locality.

**Table 1.** Mammals found in the Cata Branca and Córrego Seco RPPNs complex, Itabirito, Minas Gerais, Brazil. Place/RPPN: CB = Cata Branca; CS = Córrego Seco. Conservation status: LC = Least concern; NT = Near threatened; VU = Vulnerable; DD = Deficient in data; NC = Not cited; * = Occasional registration.

| Taxon | Common name | Local/ RPPN | Conservation state | | |
|---|---|---|---|---|---|
| | | | IUCN | ICMBIO (BR) | Biodiversitas (MG) |
| **Didelphidae** | | | | | |
| *Didelphis aurita* (Wied-Neuwied, 1826) | Big-eared Opossum | CS | LC | LC | LC |
| **Cingulata** | | | | | |
| *Cabassous tatouay* (Desmarest, 1804) | Greater naked-tailed armadillo | CS | LC | DD | NT |
| *Dasypus novemcinctus* (Linnaeus, 1758) | Nine-banded Armadillo | CB, CS | LC | LC | LC |
| **Myrmecophagidae** | | | | | |
| *Tamandua tetradactyla* (Linnaeus, 1758) | Collared anteater | CS | LC | LC | LC |
| **Callitrichidae** | | | | | |
| *Callithrix penicillata* (É. Geoffroy, 1812) | Black-tufted marmoset | CB*, CS* | LC | LC | LC |
| **Cebidae** | | | | | |
| *Sapajus nigritus* (Goldfuss, 1809) | Black Capuchin | CS | NT | NT | LC |
| **Pitheciidae** | | | | | |
| *Callicebus nigrifrons* (Spix, 1823) | Southern masked titi | CB*, CS* | NT | LC | LC |
| **Canidae** | | | | | |
| *Cerdocyon thous* (Linnaeus, 1766) | Crab-eating fox | CS | LC | LC | LC |
| *Chrysocyon brachyurus* (Illiger, 1815) | Maned Wolf | CB | NT | VU | VU |
| **Felidae** | | | | | |
| *Leopardus pardalis* (Linnaeus, 1758) | Ocelot | CB, CS | LC | LC | VU |
| *Puma concolor* (Linnaeus, 1771) | Mountain lion | CB, CS | LC | VU | VU |
| *Herpailurus yagouaroundi* (É. Geoffroy, 1803) | Jaguarundi | CS | LC | VU | DD |
| **Mustelidae** | | | | | |
| *Eira barbara* (Linnaeus, 1758) | Tayra | CB, CS | LC | LC | LC |
| *Galictis cuja* (Molina, 1782) | Lesser grison | CS | LC | LC | NC |
| **Procyonidae** | | | | | |
| *Nasua nasua* (Linnaeus, 1766) | Ring-tailed coati | CS | LC | LC | LC |
| *Procyon cancrivorus* (G. [Baron] Cuvier, 1798) | Crab-eating Raccoon | CB, CS | LC | LC | LC |
| **Cervidae** | | | | | |
| *Mazama gouazoubira* (G. Fisher, 1814) | Gray brocket | CB, CS | LC | LC | LC |
| **Caviidae** | | | | | |
| *Hydrochoerus hydrochaeris* (Linnaeus, 1766) | Capybara | CS | LC | LC | LC |
| **Cuniculidae** | | | | | |
| *Cuniculus paca* (Linnaeus, 1766) | Lowland Paca | CB, CS | LC | LC | LC |
| **Leporidae** | | | | | |
| *Sylvilagus brasiliensis* (Linnaeus, 1751) | Tapeti | CB, CS | LC | LC | NC |

Considering the entire complex of the Cata Branca and Córrego Seco RPPNs, the presence of 18 species was confirmed by means of camera traps. Two other species, black-tufted marmoset (*Callithrix penicillata*) and masked titi (*Callicebus nigrifrons*), were identified in the two reserves through their vocalizations as occasional records. For this reason, they did not enter the statistical analysis and only entered the final list of species. Therefore, the final inventory of medium and large-sized mammals in the RPPNs Complex Cata Branca and Córrego Seco was 20 species, representing 14 families of 8 different orders (Table 1, Figure 6).

The species discovery curves for Cata Branca and Córrego Seco (Figs 3, 4) show an important growth deceleration, indicating that the total number of species in the area is close to being reached. However, the estimator Jackknife 1 indicates that

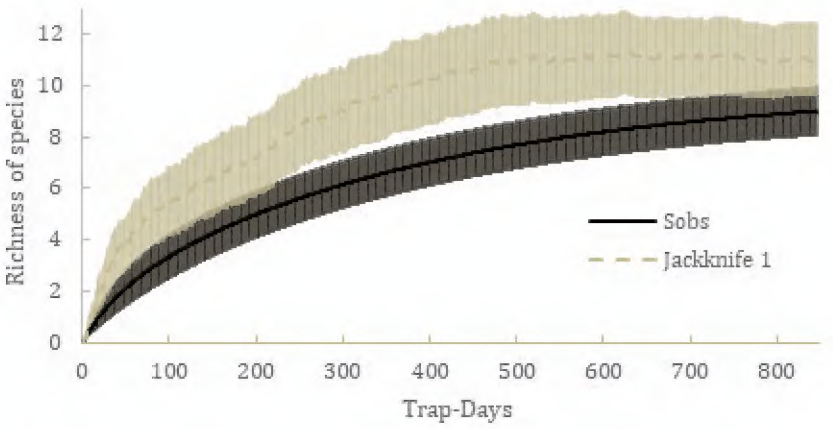


**Figure 3.** Species discovery curve with Jackknife 1 estimate at RPPN Cata Branca, Minas Gerais, Brazil.

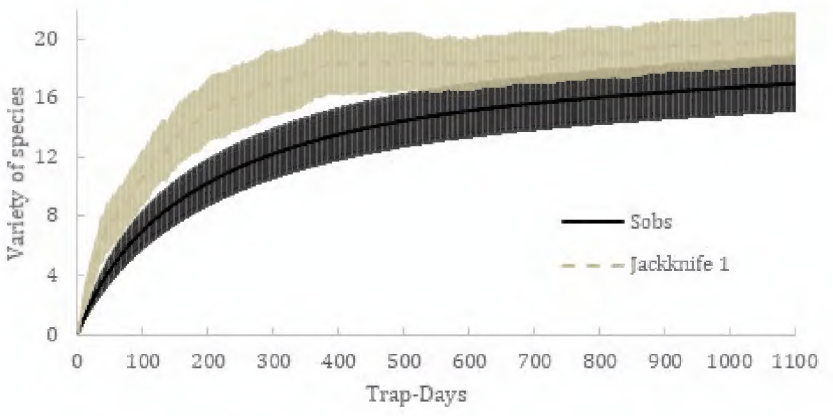


**Figure 4.** Species discovery curve with Jackknife 1 estimate at RPPN Córrego Seco, Minas Gerais, Brazil.

the RPPN Cata Branca has 11 species, two in addition to the 9 sampled, leading to a sampling efficiency of 82%. In RPPN Córrego Seco, the estimator indicates the existence of 20 species in the reserve, three more than the 17 observed, translating into a sampling efficiency of 85%.

The relative frequency of each species (Table 2, Fig. 5) reveals that *S. brasiliensis*, *C. paca* and *D. novemcinctus* were the most abundant species, with frequencies greater than 10%. This is opposed to: *S. nigritus*, *G. cuja*, *C. brachyurus* and *C. thous*, which were the least abundant species, with a relative frequency of less than 1%.

## Discussion

Local fauna inventories are extremely important to make a diagnosis of the conservation status of biodiversity in a given location. Subsequently, with the obtained data, it is important that the comparisons are made between areas, to be able to develop guidelines for identifying priority areas for species conservation (Gomes et al. 2015; Jenkins et al. 2015).

Although there are variations regarding the sampling efforts and methodologies, this work showed slightly lower numbers than other mammals' inventories carried out in other locations in the Quadrilátero Ferrífero. In Ouro Preto – MG, in the Itacolomi State Park (7,543 ha.), 29 species were listed by Melo et al. (2009), nine more species than in the present study. Even considering that the difference in species richness could be explained by the difference in the size of the areas, the

**Table 2.** Number of events and relative frequency of the species registered in the RPPN Cata Branca and in the RPPN Córrego Seco, Minas Gerais, Brazil, together.

| Species | Number of events | Relative frequency |
|---|---|---|
| *Sylvilagus brasiliensis* (Linnaeus, 1758) | 44 | 23.28% |
| *Cuniculus paca* (Linnaeus, 1766) | 36 | 19.05% |
| *Dasypus novemcinctus* (Linnaeus, 1758) | 28 | 14.81% |
| *Procyon cancrivorus* (G. Cuvier, 1798) | 18 | 9.52% |
| *Eira barbara* (Linnaeus, 1758) | 10 | 5.29% |
| *Leopardus pardalis* (Linnaeus, 1758) | 9 | 4.76% |
| *Mazama gouazoubira* (G. Fisher, 1814) | 7 | 3.70% |
| *Herpailurus yagouaroundi* (É. Geoffroy, 1803) | 6 | 3.17% |
| *Didelphis aurita* (Wied-Neuwied, 1826) | 5 | 2.65% |
| *Nasua nasua* (Linnaeus, 1766) | 4 | 2.12% |
| *Tamandua tetradactyla* (Linnaeus, 1758) | 5 | 2.65% |
| *Cabassous tatouay* (Desmarest, 1804) | 5 | 2.65% |
| *Puma concolor* (Linnaeus, 1771) | 5 | 2.65% |
| *Hydrochoerus hydrochaeris* (Linnaeus, 1766) | 3 | 1.59% |
| *Sapajus nigritus* (Goldfuss, 1809) | 1 | 0.53% |
| *Galictis cuja* (Molina, 1782) | 1 | 0.53% |
| *Chysocyon brachyurus* (Illiger, 1815) | 1 | 0.53% |
| *Cerdocyon thous* (Linnaeus, 1766) | 1 | 0.53% |
| | 189 | 100.00% |

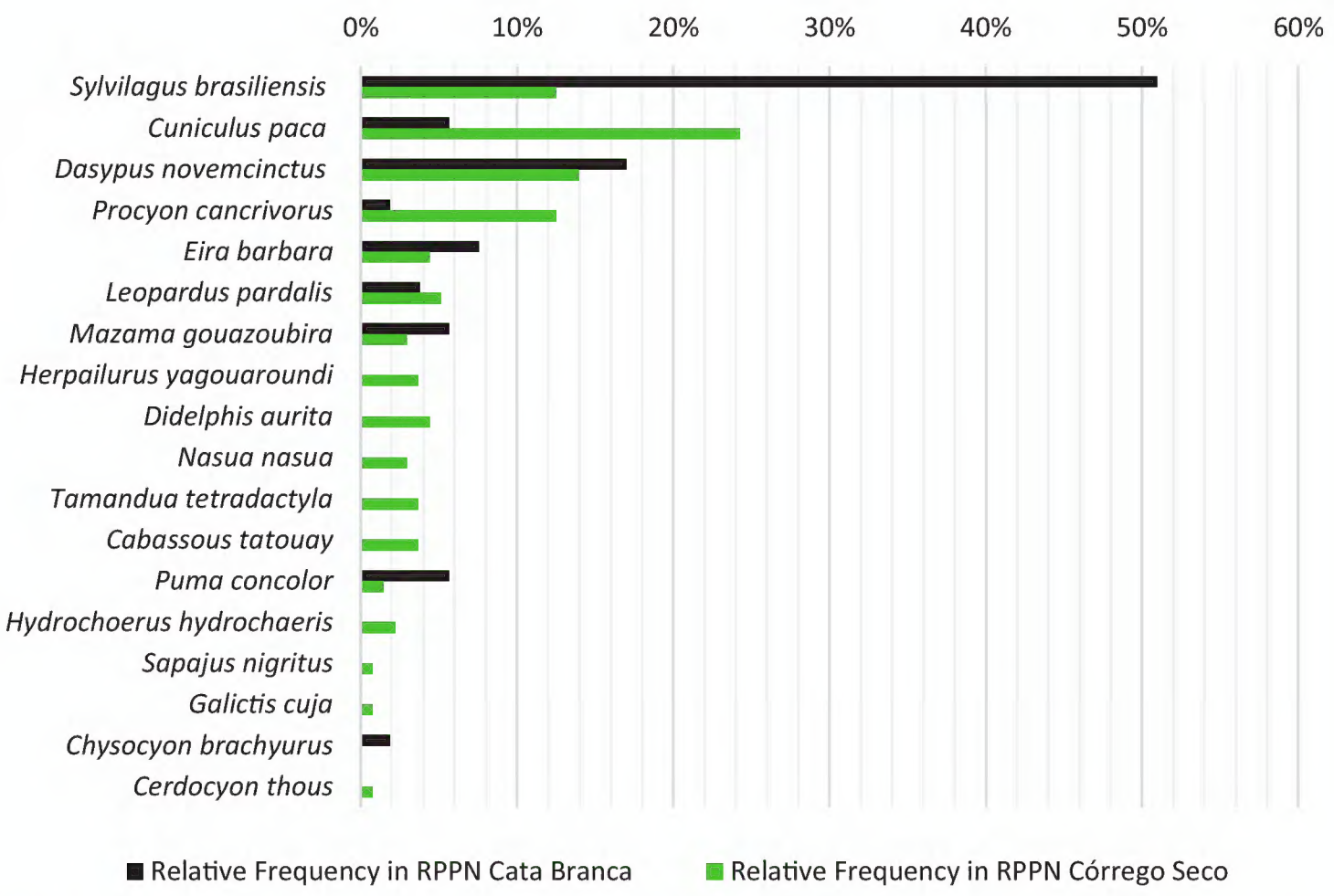


**Figure 5.** Comparison of relative frequencies in RPPN Cata Branca and RPPN Córrego Seco, Minas Gerais, Brazil, separately.

similarities in the habitat composition of the areas and their close location would indicate a greater proximity in species richness and composition. The pressures on the habitats around RPPNs may have led to a reduction in richness.

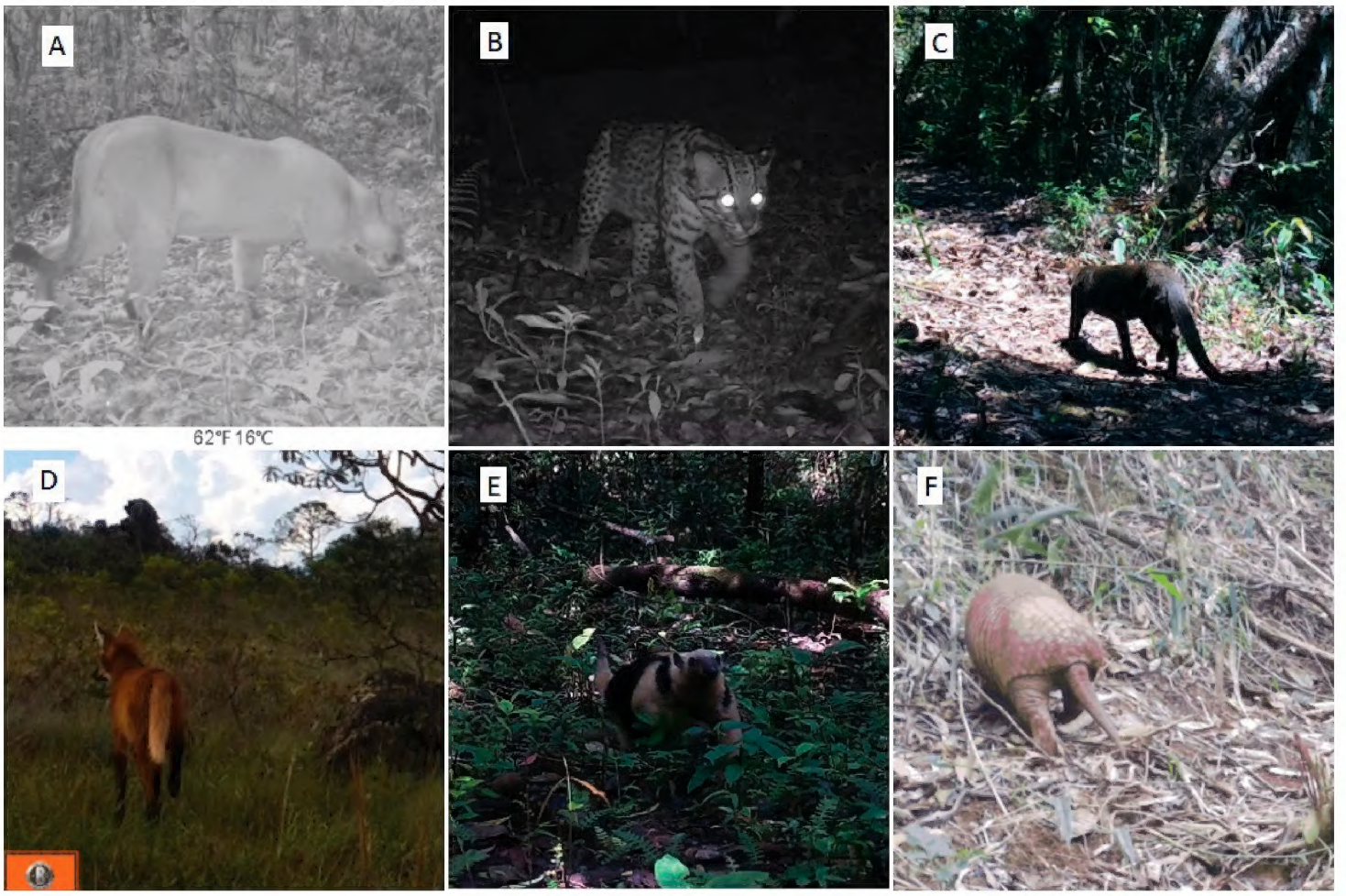


**Figure 6.** Some species registered in the RPPNs Complex Cata Branca and Córrego Seco, Itabirito, Minas Gerais , Brazil: **A)** *Puma concolor*; **B)** *Leopardus pardalis*; **C)** *Herpailurus yagouaroundi*; **D)** *Chrysocyon brachyurus*; **E)** *Tamandua tetradactyla*; **F)** *Cabassous tatouay*.

In the Serra do Rola-Moça State Park, 26 species were recorded on its 3,543 hectares located in the municipalities of Belo Horizonte, Nova Lima, Brumadinho and Ibirité (Leal et al. 2008). This indicates, once again, a certain decrease in the diversity of medium and large-sized mammals in Córrego Seco and Cata Branca. Nevertheless, Paglia et al. (2009) reported the presence of 11 species of medium and large-sized mammals in the RPPN of Mata Samuel de Paula, an area of 147 hectares in Nova Lima – MG. This is less species richness than the 20 that were listed here, but which may be related to the size difference between the reserves, considering that the RPPN of Mata Samuel de Paula has a size equivalent to 5% of the studied area in Córrego Seco e Cata Branca.

During the sampling period, several anthropic activities were recorded on the camera's trap or observed by the team, such as cyclists, motorcyclists, trash, and the presence of domestic animals and hunters, which over time may have interfered with the mammal's occurrence and explain the lower species richness in this area compared to the other areas mentioned above. The RPPN Cata Branca, in particular, appeared to be the most anthropically influenced, because only in this reserve our team met hunters with hunting dogs twice and where both camera traps were stolen. In addition, the total area of Cata Branca is about 38% smaller than that of Córrego Seco and also for having received a sampling effort 24% less. Therefore, we can indicate that these are the reasons why RPPN Cata Branca presents a lower species richness than in its neighbouring RPPN.

Nonetheless, despite the negative influences of human action within the diversity of the two locations, the importance of these two RPPNs for the conservation of species in the municipality of Itabirito is evident. From the total of species that was recorded, four are considered threatened or near threatened with extinction at the regional level (Biodiversitas 2007) and another group with four taxa comprises species listed as threatened or near threatened with extinction at a national level (ICMBIO 2018b). These are species that would probably not be there without the protection actions of a private reserve. As medium and large-sized mammals, mainly of the Carnivore class, they require relatively large areas to sustain viable populations (Costa et al. 2005). The records of *C. brachyurus*, *P. concolor* and *L. pardalis*, indicate that the dimensions of the RPPNs studied, in addition to the continuous area of the Aredes Ecological Station, may form an important mosaic in the region and, therefore, have been sufficient to support their populations. This is expected considering the vegetation component in the region which is much larger than the areas of the two RPPNs themselves, favouring the maintenance of these populations in the long run.

Observing the relative frequencies of the endangered species recorded, also provides a favourable outlook for the conservation of *L. pardalis* and *H. yagouaroundi* by revealing that they have, respectively, 4.76% and 3.17% of relative frequency. We can also include *P. concolor* which has a slightly lower percentage, by 2.65%, but which is naturally less abundant and more demanding in terms of the quality of the environment (Crawshaw 1995). However, the *Chrysocyon brachyurus* is an exception, as it is a species less demanding in relation to large areas of use and has a more general diet (Silva and Talamoni 2003), but is among the species with less relative frequency of the study, with only 0.53%.

When we analyse the two RPPNs separately (Fig. 5), we can see that both have a community with relative frequencies as expected, with smaller and generalist species with greater dominance and larger predators among the rarest (Nunes 2009). And when we compare the two areas, we can see that, except for *S. brasiliensis*, *C. paca* and *P. cancrivorus*, all species that occur in the two areas have similar relative frequencies. This indicates that the two areas have similar available resources. However, as *C. paca* and *P. cancrivorus* are very dependent on the presence of water sources for building shelters or as a food source (Cheida 2012; Figueroa-de-León et al. 2017), the greater frequency of these species in Córrego Seco can be explained by the greater availability of water in this RPPN (Oliveira 2013). Cata Branca had a relevant dominance of *S. brasiliensis* with 51% of the relative frequency in its community, however, as most of the records of this species in Cata Branca were made by only one of the camera traps, it is possible that at this point, biased data were collected and that abundance is overestimated.

## Conclusion

This study allows us to conclude that the complex of RPPNs Cata Branca and Córrego Seco has a rich diversity with 20 species of medium and large mammals,

including three species of primates and three other species threatened with extinction. Therefore, these areas provide a fundamental service for the protection of animals threatened with extinction, not only in Minas Gerais, but also throughout the national territory, in addition to harbouring very important species for the maintenance of local ecosystems. Nevertheless, it is noteworthy that these are still areas with great anthropic influence, which may be one of the reasons for the lower species record, mainly in the RPPN Cata Branca, in comparison with other reserves in the Quadrilátero Ferrífero.

It is pertinent that the area is a target for other studies, such as surveys that use linear transects, playback methodologies and the use of drones, especially for arboreal fauna. Periodic population census is fundamentally important and necessary to establish bases of comparison on the size of populations over time and to be able to identify the efficiency of reserves in preserving biodiversity.

To improve conservation, it is recommended that the company carry out educational steps to raise the population's awareness about the nature of a Private Natural Heritage Reserve and its importance, establish dialogue with cycling and motocross athletes to regulate ways of using the trails without damage to the reserve, improve the surveillance actions to avoid hunters and, finally, provide studies for management of the dog populations found inside their forests.

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